PRELAUNCH ACTIVITIES AND PLANNING SPACECRAFT INTEGRATION AND TEST

GENE KEELING
AM-1 I&T Manager

Lockheed Martin Missiles and Space
Valley Forge, PA
E-mail: gkeeling@eos.vf.mmc.com

Spacecraft I&T Basic Principles

- Repeatable (automated/parallel)
- Integrated
- Traceable
- Realistic
- Testing is only performed to authorized, written procedures
- All testing done at spacecraft level is based on testing done at lower levels of assembly

Spacecraft I&T Responsibilities

- I&T Test Engineers
  - All spacecraft integration, test, and launch site operations
  - Review and approval of all spacecraft test-related information (e.g., test procedures, database, memory/data loads, displays)
  - Configuration management of all test-related information
  - Housekeeping data monitoring and evaluation; review of all test results
- Flight Operations
  - Validate command and telemetry database
  - Develop EOC compatibility test procedures
  - Coordinate EOC testing with spacecraft
  - Coordinate transfer of test-related information necessary for flight operations

Spacecraft I&T Responsibilities (Cont'd)

- Instrument Providers
  - Provide instrument-specific, test-related information
  - Define science data processing requirements; evaluate science data
  - Certify instrument performance
- Subsystem Engineers
  - Review and approval of all spacecraft test procedures
  - Review and approval of test results; certify launch readiness
  - Provide technical support, as required

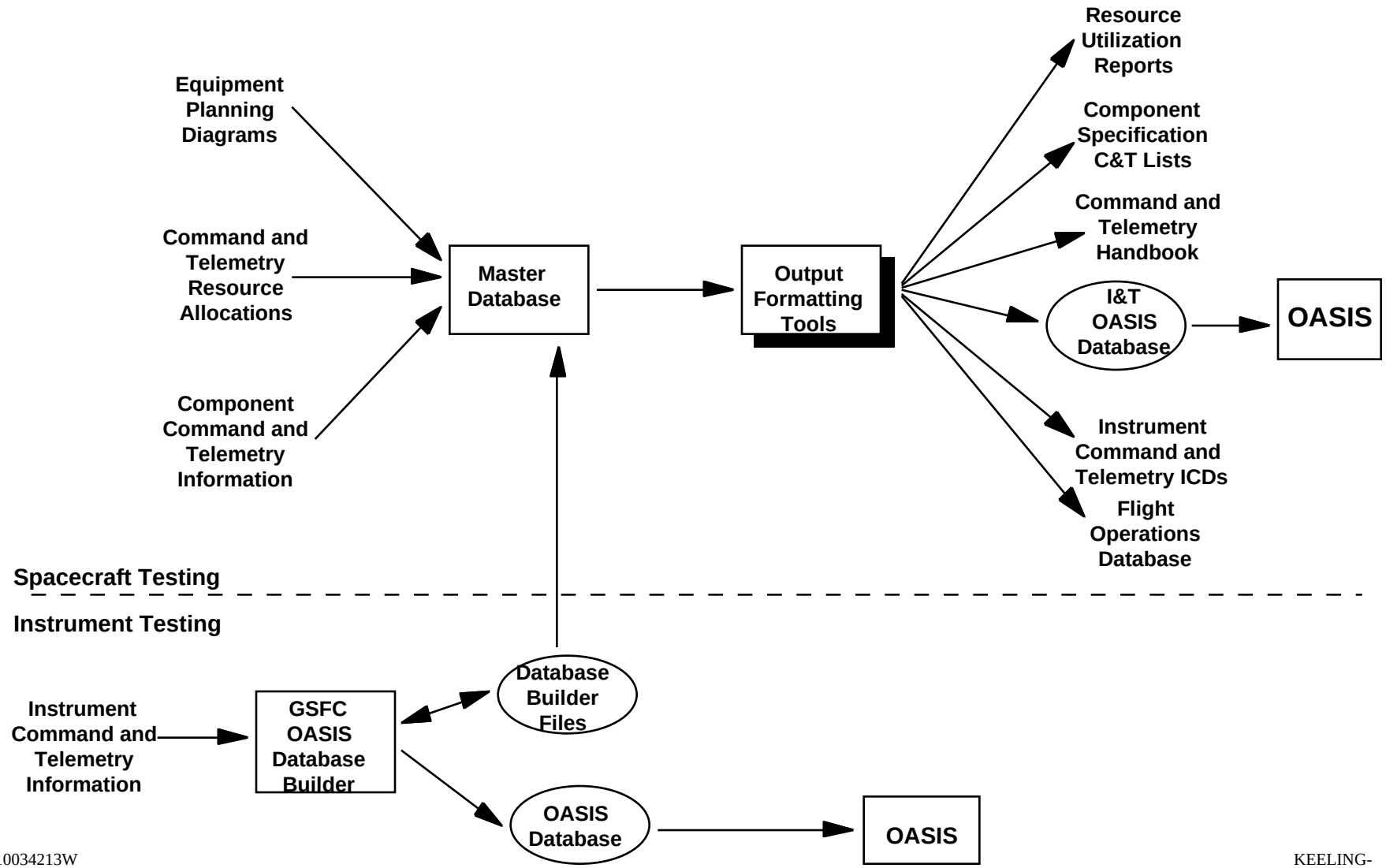
OASIS

- Command and control software used in SCS for I&T
- Developed by University of Colorado [Government-furnished equipment (GFE)]
- Provides CSTOL test language
- GSFC is requiring that Instrument Providers use OASIS

  The same test procedures and database used for testing at instrument level will be used for testing at spacecraft level!

- To ensure compatibility, I&T has defined conventions for OASIS
  - Building blocks – test procedures that perform a single function; combined to create integrated test procedures
  - Database – command, telemetry, limits, calibration
  - Displays

Ground Support Equipment Software Master Database



Data Processing in I&T Facility

- Housekeeping data
  - I&T is responsible for monitoring all spacecraft health and safety parameters
  - Data will be displayed, monitored, and limit checked in real time
  - Predefined offline analysis is performed on housekeeping data every 2 hours
  - All housekeeping data is permanently archived on optical disk
  - Housekeeping data is also temporarily (~3 weeks) archived on analog tape that is available for playback; this media can be permanently archived for selected key events
- Science data
  - Instrument Providers responsible for evaluating science data
  - I&T processing of science data limited to recognition of test patterns
  - I&T will receive, permanently archive, and distribute all science data (based on VCID)
  - Sufficient capability must exist onsite (I&T) to detect anomalies in science data within 24 hours after completion of a test

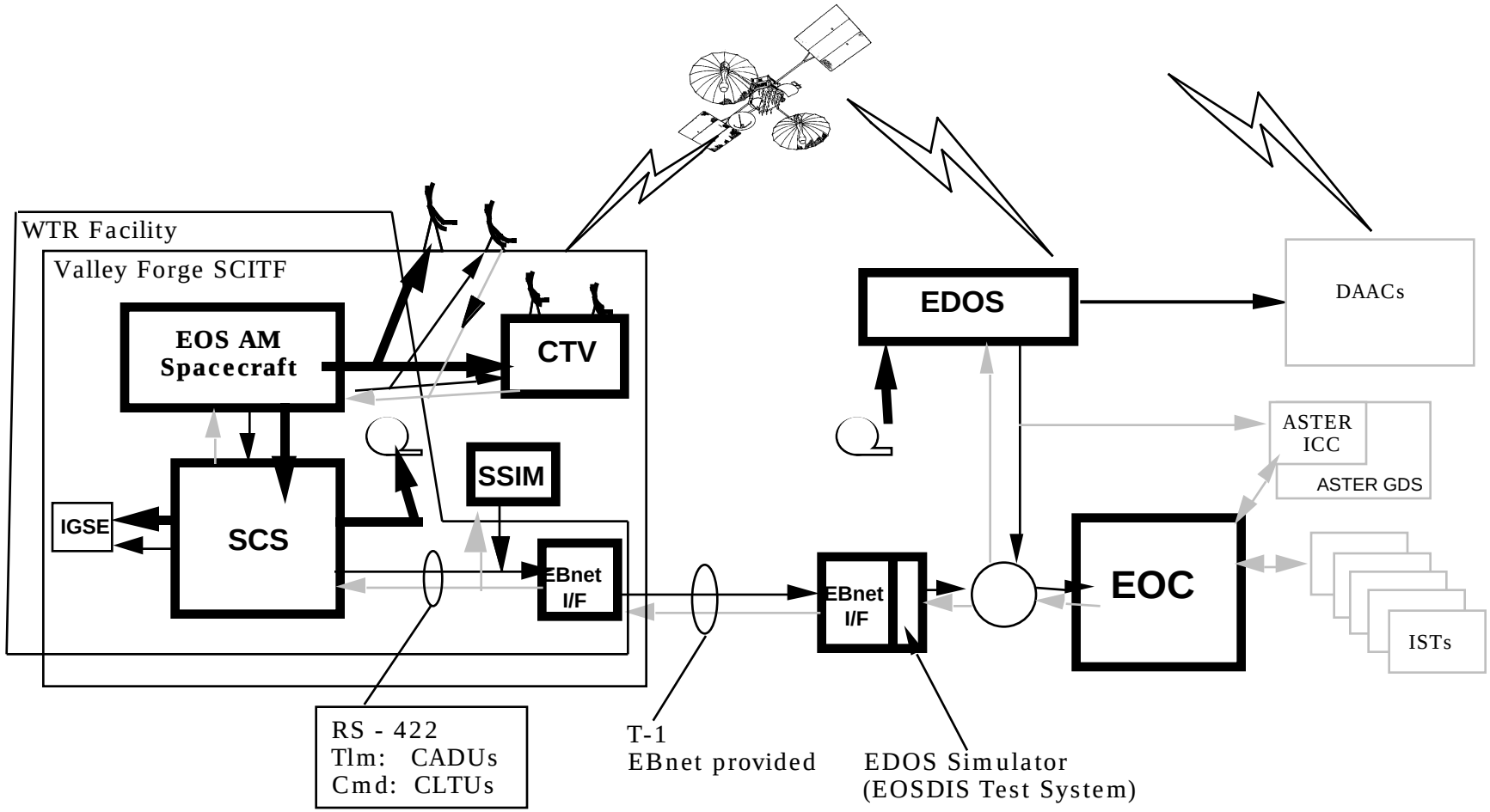
Ground Support Equipment

- Electrical ground support equipment (EGSE) used to support I&T
- Spacecraft interface simulator (SIS)
  - Used to demonstrate instrument interface compatibility with spacecraft and SCS prior to instrument delivery
  - Provides test environment with same “look and feel” as SCS
- Spacecraft checkout station (SCS)
  - Consists of all equipment necessary to test the spacecraft [less instrument-unique ground support equipment (GSE)]
  - Automated system based on Sun workstations running OASIS
  - Distributed architecture supports various test configurations
- Instrument ground support equipment (IGSE)
  - Includes all instrument-unique equipment necessary to support instrument integration to spacecraft
  - Consists of all equipment necessary to process instrument science data
  - Includes any instrument-unique targets/stimuli and fixturing

Spacecraft Checkout Station

- Hardline EOC interface with spacecraft will be via SCS command
  - Hardline command interface is via Sun workstation and RS-422
  - Commands must be in form of CLTUs
  - All commands (via hardline) will be compared against a “not allowed" list and will be rejected if there is a match
  - Software switch will direct transmitted commands (via hardline) to either the spacecraft or a disk file
- Housekeeping telemetry
  - Hardline telemetry interface is via RS-422 interface on bit sync
  - Telemetry will be in form of CADUs (CLCW is not extracted)
- Science data
  - Data can only be provided real time via TDRSS
  - Data can be provided in non-real time via tape
- Spacecraft simulator
  - Part of SCS used to verify proper test configuration prior to connecting SCS to spacecraft
  - Can receive and process commands (CLTUs) and generate 1- and 16-kbps telemetry (CADUs, however, not RS encoded!)
  - Can be used to support EOC interface checkout in advance of testing with spacecraft

Spacecraft I&T End-to-End Data Flow



EOC Testing With Spacecraft

- Test preparation
  - I&T will provide command and telemetry database information in ECS contractor-specified format
  - Flight operations team will develop compatibility test procedure(s)
  - EOC command database validation test will be performed; test consists of transmitting each command to SCS
- Shadow (or listening) mode (via dedicated communications link)
  - Spacecraft housekeeping telemetry can be provided to EOC essentially any time spacecraft is powered
- EOC compatibility testing
  - Consists of multiple tests, each one building on previous one
  - Some tests can be performed hardline, some require TDRSS (those requiring TDRSS will be performed after TDRSS compatibility test)
  - Demonstrates various command rates, various command types and destinations, various telemetry rates, recorder playbacks, memory loads, and flight software commanding
  - Verifies procedure timing and validates activity timelines

RF Compatibility Testing

- SN (S- and Ku-band) compatibility testing
  - Via Compatibility Test Van (CTV) or roof top antennas
  - Verifies compatibility between spacecraft, TDRS, and ground segment elements
  - All communication links are tested
- Contingency ground station (S-band) compatibility testing (WOTS, AM-1 Backup Stations)
  - Via CTV
  - EOC links to ground stations verified using tapes
- DAS (X-band) compatibility testing (AM-1 Backup Stations)
  - Via CTV
  - EOC links to ground stations verified using tapes

Launch Site Operations Overview

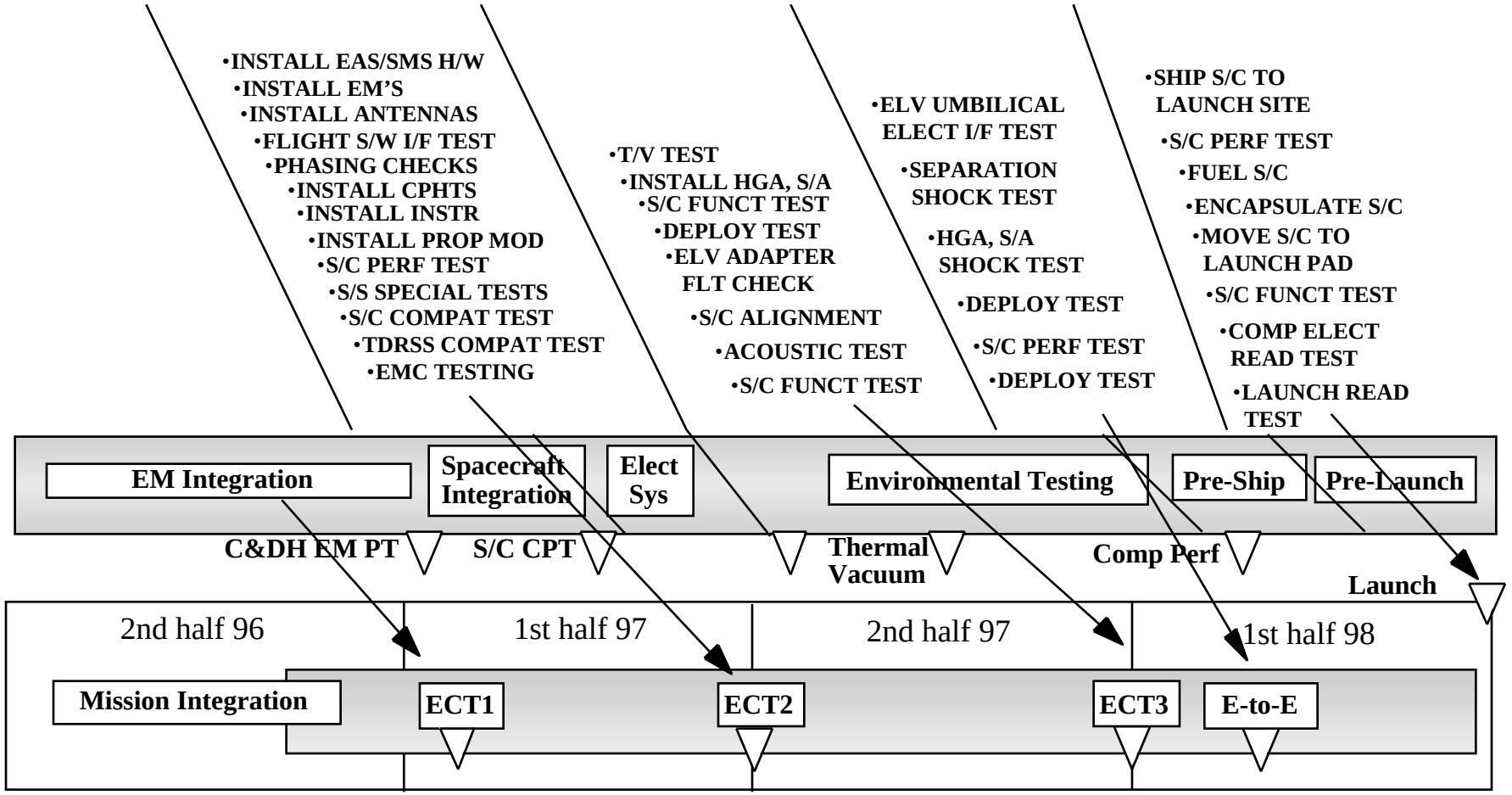
- EOS AM-1 will be launched from SLC-3E at Vandenberg Air Force Base onboard an Atlas II AS launch vehicle
- Launch date is June 30, 1998
- Spacecraft processing will be performed at Astrotech with same SCS-to-EOC communication configuration
- Three spacecraft tests scheduled with EOC while spacecraft is at launch site
  - Hardline telemetry data flow [during spacecraft Comprehensive Performance Test (CPT)]
  - Launch pad testing rehearsal (hardline telemetry and No-Op command)
  - Launch rehearsal (hardline telemetry and No-Op command)

EOC Testing Guidelines

- All testing with EOC will use preapproved procedures
  - I&T will be provided with a copy of procedure prior to start of test
- I&T will have final authority for all testing that involves the spacecraft
- All EOC test procedures must be validated prior to being used with the spacecraft
- Testing will be coordinated via voice links
- If problems are encountered, testing will proceed at I&T's discretion; if necessary, testing will be suspended and rescheduled

I&T will continuously monitor spacecraft parameters during all operations testing!

Spacecraft I&T Flow



Spacecraft Data Availability

Data Available Outside Test Facility

Test	Purpose	1 Kbps	16 Kbps	SSR HK 256 Kbps	Science Data	Command	Date
Spacecraft Bus Comprehensive Performance Test		●	●				**JAN 97**
Spacecraft Comprehensive Performance Test		●	●	● ◯	◯		**MAY 97**
EOC Compatibility Test	Demonstrate EOC Command & Telemetry Database integrity	●	●	● ◯		●	**Jan 97 Jul 97 Jan 98**
Spacecraft Compatibility Test (1, 2, 3)	RF Compatibility with TDRSS	🛰	🛰	🛰	◯ 🛰	🛰	**MAY 97**
Spacecraft Thermal Vacuum Test		●	●	● ◯	◯		**AUG-OCT 97**
Spacecraft Comprehensive Performance Test (post acoustics)		● ◯	● ◯	● ◯ 🛰	◯ 🛰		**FEB 98**
Spacecraft End to End Test	Compatibility SC to Ground elements	● 🛰	● 🛰	● ◯ 🛰	◯ 🛰	● 🛰	**MAR 98**
Mission Operations Simulation 100 hrs trouble free ops	Demonstrate ground readiness Nominal / Contingency procedure checkout & timing	● 🛰	● 🛰	● ◯ 🛰	◯ 🛰	● 🛰	**MAR 98**
Spacecraft Comprehensive Performance Test (Post Ship)		●	●	● ◯	◯		**MAY 98**
Spacecraft Launch Pad Comm Test	Demonstrate Command & Telemetry integrity	●	●			●	**JUN 98**

● **Data via EBnet (Hardline)** ◯ **Data tape**

🛰 **Data via TDRSS (S band Ku Band) (rooftop or CTV)**